AN EXPERIMENTAL STUDY ON THE INTERRUPTION OF THE PORTAL VEIN

AUTHOR(S):

OYANAGI, TAKASHI

CITATION:

OYANAGI, TAKASHI. AN EXPERIMENTAL STUDY ON THE INTERRUPTION OF THE PORTAL VEIN. 日本外科宝函 1963, 32(4): 506-523

ISSUE DATE:

1963-07-01

URL:

http://hdl.handle.net/2433/205542

AN EXPERIMENTAL STUDY ON THE INTERRUPTION OF THE PORTAL VEIN

By

TAKASHI OYANAGI

From the 2nd Department of Surgery Kanazawa University, Medical School
(Director : Prof. Dr. ICHIO HONJO)

Received for publication Jun. 6, 1963

CONTENT

I. INTRODUCTION

It is well known that the interruption of the portal vein invariably results in death of experimental animals within a few hours. Many experimental reports and clinical observations have been made on the portal interruption.

ORE[1] demonstrated, in 1856, that in rabbits the portal interruption results in death shortly afterwards. SCHIFF[2], and later BERNARD[3] also reported that dogs died abruptly within an hour after portal interruption. On the contrary, SOLOWIEFF[4] demonstrated that dogs can survive the interruption when the portal branches are ligated one by one with certain interval of time and finally the portal trunk is ligated. According to Popper's REPORT[5] animals can survive the complete occlusion of the portal vein if the interruption is performed after 2 weeks' gradual constriction of the portal vein.

On the other hand, CHILD[6] demonstrated that monkeys can bear the acute portal interruption.

There have been many discussions concerning the cause of death of dogs following

the acute and complete interruption of the portal vein. SCHIFF[2] attributed the cause of death to hepatic failure, BERNARD[3] to congestion in the splanchnic area and THÖLE[7] asserted neurogenic theory based upon his experimental results that permissible time of portal interruption was prolonged by severance of the splanchnic nerve. ELMAN and COLE[8] pointed out a profound decrease in circulating blood volume as the cause of death, namely they showed that following portal interruption blood is pooled from systemic circulation to the intestinal tract which amounts as much as 5.2 per cent of body weight within an hour, and from this point they reported that prolongation of permissible time of portal interruption could be observed by transfusion. KRYMHOLZ[9] also accentuated irreversible profound drop of arterial pressure after portal interruption. SHORR and others[10] likewise attributed the cause of death after portal interruption to decrease in circulating blood volume and hypoxia.

Following experiments were designed according to the intention of the author of the present paper to prolong permissible time of portal interruption which assures the survival of the animals and at the same time to explore the cause of death after portal interruption.

Ⅱ. MATERIALS AND METHODS

1. Materials. Mongrel dogs weighting 7 to 23 kg were used.
2. Anesthesia. Anesthesia was introduced by intravenous injection of isomithal sodium of 15 mg per kg body weight and after intubation it was maintained with ether in 2 or 3 plane of the 3 rd stage.
3. Operative procedure. Abdomen was opened by the upper median incision, which was added by the right transverse incision.

a) Interruption of the portal vein.

The portal vein was separated from the surrounding tissues for about 2 cm from the porta hepatis. The interruption of the portal vein was performed as near the porta hepatis as possible. At this procedure, when the pyloric vein was draining to the portal trunk at liver-side of the interruption, the pyloric vein was additionally ligated (Fig. 1), since marked congestion was observed in this vein after the portal interruption.

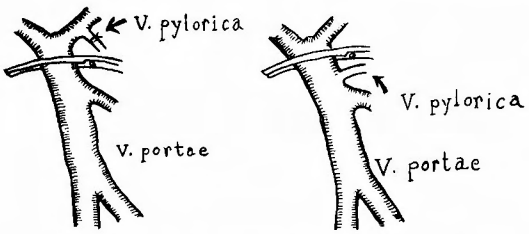


Fig. 1. Site of the interruption of the portal vein.

b) Interruption of the superior and inferior mesenteric arteries.

The superior and inferor mesenteric arteries were separated from the surrounding tissues for about 1 cm, respectively, from their origin from the abdominal aorta and interrupted.

c) Splenectomy

The vessels at the hilum of the spleen were ligated and cut, and the spleen was removed.

In the cases in which operation of b) or c) was performed, the portal vein was interrupted 5 minutes after the accomplishment of the preceding procedures. In order to

prevent the injury of the vessel-wall at the interruption, Pèan's clamp was covered with rubber and used.

4. Combination of the interruption modus of blood flow and number of dogs in each combination.

Group A. Simple portal interruption, 14 dogs.

Group B. Interruption of the portal vein and the superior mesenteric artery, 8 dogs.

Group C. Interruption of the portal vein and the superior and inferior mesenteric arteries, 10 dogs.

Group D. Interruption of the portal vein and splenectomy, 9 dogs.

Group E. Interruption of the portal vein and the suporior and inferior mesenteric arteries and splenectomy, 19 dogs.

5. Examinations.

a) Permissible time of the portal interruption.

Interruption was performed for 30, 45, 60 and 90 minutes in above mentioned each group. Animals which survived more than 48 hours after the release of each interruption were recorded as survivor.

The longest duration of the interruption in which survival rate was more than 60 per cent was decided to be permissible time of the portal interruption.

b) Arterial pressure.

Arterial pressure was continuously measured through a polyethylene tube inserted into the right femoral artery, which was connected to a mercurial manometer.

c) Portal pressure.

Portal pressure was measured with aqueous manometer through a polyethylene tube inserted from the splenic vein to the portal trunk. Portal pressure actually measued was converted to the mercurial term.

d) Serum transaminase.

Serum transaminase was determined following the method of CAUBAUD, LEEPER and WRÖBLESKI[11], using blood drawn from the left femoral vein.

6. Reagents.

i) Aspartic acid-glutaric acid reagent.

dl-aspartic acid of 2.66 g, α-ketoglutaric acid of 0.6 g and primary potassium phosphate of 2.00 g were dissolved in 100 ml of distilled water, and the reaction was adjusted to pH 7.4.

ii) Aniline citrate reagent.

Citric acid of 5 g was solved in 5 ml of water and 5 ml of aniline was added.

iii) 100 per cent trichloracetic acid.

Trichloracetic acid of 100 g was dissolved in distilled water and finally made 100 ml.

iv) 2-4, dinitrophenol hydrazine reagent.

Aniline citrate of 0.1 g was solved in 20 ml of 37 per cent hydrochloric acid and diluted with water finally to be 100 ml.

v) Toluene.

Toluene of 100 ml was solved in 10 to 15 ml of water and stored in shadowed bottle at 4°C.

vi) 25 per cent KOH alchohol solution.

Caustic potash of 2.5 g was solved in ethanol of 95 per cent and adjusted to be 100 ml and tightly sealed for preserve.

7. Determination.

i. Serum of 0.5 ml is put in each of 2 test tubes and 0.5 ml of distilled water and 0.5 ml of aspartic acid are added to each of them.

ii. One drop of trichloracetic acid and aniline citrate are immediately added to the first test tube for control.

iii. To the second test tube, the same procedure as in ii) is performed after reaction of 20 minutes at 37°C.

iv. 2-4, dinitrophenol hydrazine of 0.5 ml is added to each of these test tubes. Contents are well mixed and left for 5 minutes.

v. Toluene of 4ml is added to above mentioned mixture, vigorously shaken and centrifuged for 5 minutes. One ml of toluene layer is pipetted in and transfered to cubett.

vi. KOH-alchohol of 3.0 ml is added to this and well mixed.

vii. Colorimetry is performed through a filter of 450 mμ. SGO-T activity is obtained from the standard curve.

8. Drawing of the standard curve.

Pyruvic acid of 1g is solved in 1000 ml of distilled water. A series of pyruvic acid solution of 1μg/ml to 500μg/ml is prepared. Absorbability of each material is determined against blank of distilled water with colorimeter as mentioned in the above and the standard curve is drawn.

e) Electrocardiographic study.

Electrocardiogram was taken by limb and chest leads.

f) Histological study.

Small intestine, liver and heart are doubly stained with hematoxylin and eosin.

Ⅲ. RESULTS

1. Permissible time of portal interruption.

Permissible time and postoperative course of each group are summarized in Table 1 to 5. In the Group A, B, C and D, portal interruption was performed for 30, 45 and 60 minutes, respectively. In the Group E the interruption was continued for 30, 45, 60, 75 and 90 minutes.

In the Group A, 5 cases out of 7 of 30 minutes' interruption survived. On the contrary, all of 4 cases of 60 minutes' interruption died. Accordingly the permissible time of the Group A is 30 minutes.

In the Group B, all of 3 cases of 30 minutes' interruption, 1 case out of 3 of 45 minutes' interruption survived. Both of 2 cases of 60 minutes' interruption died. Accordingly the permissible time of the Group B is 30 minutes.

In the Group C, all of 4 cases of 30 minutes' interruption, 2 cases out of 3 of 45 minutes' interruption survived and all of 3 cases of 60 minutes' interruption died. Accordingly the permissible time of the Group C is 45 minutes.

In the Group D, 2 cases out of 3 of 30 minutes' interruption, 1 case out of 3 of

Tab. 1. Results of the portal vein interruption in Group A.

NO. OF DOGS	WEIGHT (kg)	SEX	PERIODS OF OCCLUSION (Min.)	RESULT
1	7.1	♂	30	survival
2	13.9	♂	30	died
3	8.3	♀	30	survival
4	10.3	♂	30	survival
5	12.5	♀	30	survival
6	7.8	♂	30	survival
7	13.2	♂	30	died
8	8.5	♀	45	survival
9	10.0	♂	45	died
10	9.6	♀	45	died
11	8.2	♂	60	died
12	9.3	♂	60	died
13	12.4	♀	60	died
14	7.8	♀	60	died

Tab. 2. Results of the portal vein interruption in Group B.

NO. OF DOGS	WEIGHT (kg)	SEX	PERIODS OF OCCLUSION (Min.)	RESULT
15	8.4	♀	30	survival
16	13.4	♂	30	survival
17	9.1	♂	30	survival
18	10.4	♂	45	survival
19	7.6	♀	45	died
20	20.4	♀	45	died
21	16.4	♂	60	died
22	7.2	♀	60	died

Tab. 3. Results of he portal vein interruption in Group C.

NO. OF DOGS	WEIGHT (kg)	SEX	PERIODS OF OCCLUSION (Min.)	RESULT
23	12.4	♀	30	survival
24	9.4	♂	30	survival
25	8.5	♀	30	survival
26	14.0	♂	30	survival
27	23.2	♂	45	survival
28	14.6	♀	45	died
29	7.8	♀	45	survival
30	8.8	♀	60	died
31	10.6	♂	60	died
32	12.1	♂	60	died

Tab. 4. Results of the portal vein interruption in Group D.

NO. OF DOGS	WEIGHT (kg)	SEX	PERIODS OF OCCLUSION (Min.)	RESULT
33	10.1	우	30	survival
34	7.2	♂	30	survival
35	13.4	♂	30	died
36	18.8	우	45	survival
37	9.4	우	45	died
38	10.4	우	45	died
39	8.4	♂	60	died
40	8.0	♂	60	died
41	7.8	♂	60	died

Tab. 5. Results of the portal vein interruption in Group E.

NO. OF DOGS	WEIGHT (kg)	SEX	PERIODS OF OCCLUSION (Min.)	RESULT
42	10.6	♂	30	survival
43	8.8	우	30	survival
44	9.9	우	30	survival
45	7.8	우	45	survival
46	20.0	♂	45	survival
47	9.6	♂	45	died
48	7.4	우	45	survival
49	23.0	♂	60	survival
50	8.2	우	60	survival
51	7.8	우	60	died
52	9.4	♂	60	survival
53	20.4	♂	60	survival
54	10.5	♂	60	survlval
55	9.8	♂	75	died
56	8.4	우	75	died
57	7.4	우	75	died
58	22.4	♂	90	died
59	28.4	♂	90	died
60	8.7	우	90	died

45 minutes' interruption survived and all of 3 cases of 60 minutes' interruption died. Accordingly the permissible time of Group D is 30 minutes.

In the Group E, all of 3 cases of 30 minutes' interruption, 3 cases out of 4 of 45 minutes' interruption, 5 cases out of 6 of 60 minutes' interrption survived and all of 3 cases of 75 minutes' interruption and similarly all of 3 cases of 90 minutes' interruption died. Accordingly the permissible time of the Group E is 60 minutes.

As has been shown, the permissible time is 30 minutes in the Group A, B and D, 45 minutes in the Group C and 60 minutes in the Group E. Thus twice as much prolonged permissible time of the portal interruption was observed by adding interruption of the superior and inferior mesenteric arteries and splenectomy compared with that of

simple portal interruption.

2. Macroscopic changes in the abdominal organs after portal interruption.

In the Group A, the first change was observed 5 minutes after the interruption of the portal vein at 25 cm anal side of the small intestine from the pylorus, i. e. the surface of the intestine changed into dark red which gradually appeared on the stomach, duodenum and large intestine. Color of intestinal surface further changed into dark violet, peristalsis disappeared and petechia appeared on the mesenterium. The liver seemed to shrink and its tincture to faint which restored, however, to the state before the interruption a few minutes later. In the Group E, anemic discoloration was observed in the intestinal surface after the interruption of the superior and inferior mesenteric arteries. Gastrointestinal surface gradually turned into dark violet after portal interruption. Development of the changes in the intestine after portal interruption in the Group E was more mild than in the Group A, and bleeding to the mesenterium was hardly observed in the Group E.

Autopsy of the dead animals disclosed conspicuous congestion and edema in the spleen stomach, small and large intestines. Massive bleeding was observed in the intestinal

Tab. 6. Changes in arterial pressure after portal interruption in Group A.

NO. OF DOGS	BEFORE OCCLUSION OF THE P. V.	AFTER OCCLUSION OF THE P. V. (Min.)				AFTER RELEASE OF THE P.V. (Min)		
		5	10	20	30	10	20	30
1	100	63	58	52	52	60	68	100
3	98	63	52	48	56	70	78	76
4	120	68	66	60	58	64	74	104
5	130	88	80	74	58	82	90	108
6	88	61	50	48	43	52	61	78
	BEFORE OCCLUSION OF THE P. V.	AFTER OCCLUSION OF THE P.V. (Min.)						
		8	10	20	30	40	50	60
11	96	60	55	51	47	41	38	32
12	90	52	48	43	38	36	34	30
13	100	65	60	55	50	44	41	35
14	82	50	47	46	42	38	32	28

THE P. V. : THE PORTAL VEIN

Tab. 7. Changes in arterial pressure after portal interruption in Group E.

NO OF DOGS	BEFORE OP.	DIRECTLY AFTER SPLENECTOMY	5Min. AFTER OCCLUSION OF THE SUP., INF. MESENTERIC ARTERIES	AFTER OCCLUSION OF THE P. V. (Min.)						
				5	10	20	30	40	50	60
49	101	89	114	83	80	77	74	70	68	65
50	81	66	86	72	70	69	65	63	62	62
52	95	87	110	72	72	72	70	68	67	65
53	110	100	121	88	85	81	80	79	79	78

THE P. V. : THE PORTAL VEIN

canal.

Here the arterial pressure, portal pressure, SGO-T activity, electrocardiogram and histological finding of the Group A, which showed the shortest permissible time of portal interruption, were compared with those of the Group E, which showed the longest permissible time.

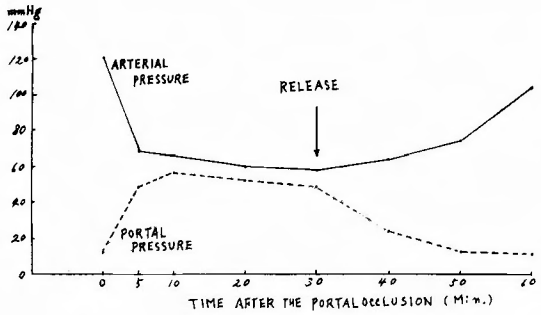


Fig. 2. Changes in arterial and portal pressures after portal interruption in Group A (Dog No. 4).

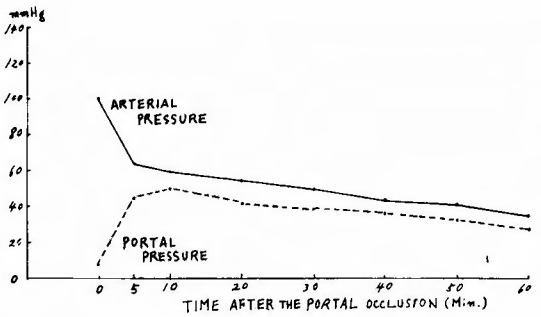


Fig. 3. Changes in arterial and portal pressures after portal interruption in Group A (Dog No.13).

3. Changes in the arterial pressure after portal interruption (Tab. 6, 7, Fig. 2, 3, 4).

In the Group A (Dog No. 1 to 6), arterial pressure fell by 27 to 52 mmHg 5 minutes after the interruption, which further decreased on and 30 minutes after the interruption arterial pressure reached below 60 mmHg in all cases. Arterial pressure gradually restored after release of the interruption and returned to the level before the interruption 30 minutes after the release.

On the other side, in the Group E, arterial pressure decreased by 11 to 22 mmHg after splenectomy and increased by 20 to 25 mmHg after the interruption of the superior and inferior mesenteric arteries. Roughly, the same tendency of fall was observed

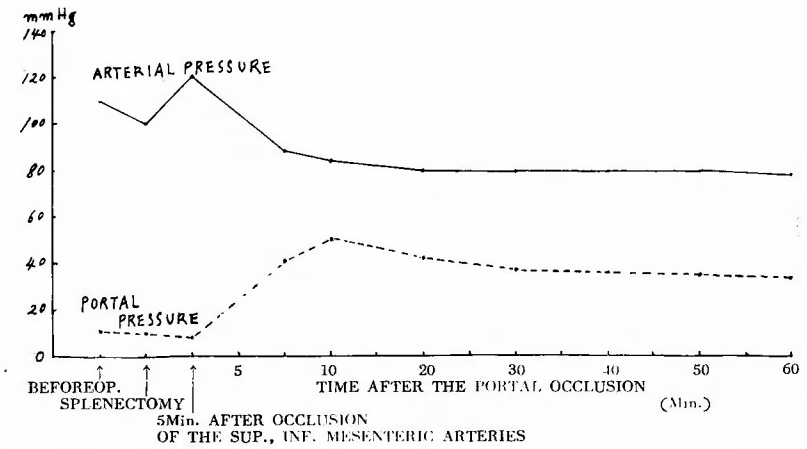


Fig. 4. Changes in arterial and portal pressures after portal interruption in Group E (Dog No. 53).

after portal interruption, i. e. decrease of 14 to 38 mmHg 5 minutes after the interruption. Although the pressure showed further tendency of decrease, the range of decrease was more slight compared with that of the Group A, the pressure being above 60 mmHg even 30 minutes after the interruption.

4. Changes in portal pressure after portal interruption (Tab. 8, 9, Fig. 2, 3, 4).

Tab. 8. Changes in portal pressure after the portal interruption in Group A.

NO. OF DOGS	BEFORE OCCLUSION OF THE P. V.	AFTER OCCLUSION OF THE P. V. (Min.)				AFTER RELEASE OF THE P.V. (Min.)		
		5	10	20	30	10	20	30
1	8	40	42	43	45	20	10	10
3	6	38	40	32	34	18	14	8
4	12	48	56	52	49	24	13	12
5	12	56	62	60	42	18	16	14
6	6	41	38	29	25	14	11	10
	BEFORE OCCLUSION OF THE P. V.	AFTER OCCLUSION OF THE P.V. (Min.)						
		5	10	20	30	40	50	60
11	8	42	48	49	31	27	25	21
12	7	39	42	41	32	22	20	20
13	8	45	50	42	39	36	34	28
14	6	36	32	30	28	27	25	18

THE P. V. : THE PORTAL VEIN

Tab, 9. Changes in portal pressure after the portal interruption in Group E.

NO. OF DOGS	BEFORE OP.	DIRECTLY AFTER SPLENECTOMY	5Min. AFTER OCCLUSION OF THE SUP., INF. MESENTERIC ARTERIES	AFTER OCCLUSION OF THE P. V. (Min.)						
				5	10	20	30	40	50	60
49	10	10	8	36	40	48	46	41	38	35
50	6	6	6	32	34	34	32	30	30	27
52	8	6	6	41	44	40	38	32	31	28
53	11	10	7	31	39	42	37	35	34	34

THE P. V. : THE PORTAL VEIN

In the Group A (Dog No. 1 to 6), portal pressure was elevated abruptly, reaching its maximum with elevation of 34 to 50 mmHg 5 to 10 minutes after the interruption, in other words coming near the level of arterial pressure with only small difference from it. Portal pressure thereafter gradually fell in parallel with arterial pressure. On the other side, in the Group E, fluctuation of portal pressure caused by splenectomy or interruption of the superior and inferior mesenteric arteries was not so marked. Maximum portal pressure after the interruption of the portal vein in this group was observed 10 to 20 minutes after the interruption, which was 28 to 38 mmHg higher than that before the interruption. Difference between portal and arterial pressure was larger than in the Group A, and portal pressure thereafter decreased together with arterial pressure.

5. Changes in SGO-T activity after portal interruption (Tab. 10, 11, 12, Fig. 5, 6, 7).

Tab. 10. Values of SGO-T activity after 30 minutes' interruption in Group A.

NO. OF DOGS	BEFORE OCCLUSION OF THE P. V.	DIRECTLY AFTER RELEASE OF THE P. V.	AFTER RELEASE OF THE P. V. (h.)			
			1	24	48	72
1	46	92	105	182	124	35
3	23	65	82	104	95	28
4	72	92	121	202	252	124
5	72	101	134	280	254	121
6	53	65	88	172	198	112

THE P. V. : THE PORTAL VEIN

Tab. 11. Values of SGO-T activity after 30 minutes' interruption in Group E.

NO. OF DOGS	BEFORE OCCLUSION OF THE P. V.	DIRECTLY AFTER RELEASE OF THE P. V.	AFTER RELEASE OF THE P. V. (h.)			
			1	24	48	72
42	45	47	49	51	93	38
43	34	38	42	44	32	34
44	52	60	63	65	38	32

THE P. V. : THE PORTAL VEIN

Tab. 12. Values of SGO-T activity after 60 minutes' interruption in Group E.

NO. OF DOGS	BEFORE OCCLUSION OE THE P. V.	DIRECTLY AFTER RELEASE OF THE P. V.	AFTER RELEASE OF THE P. V. (h.)			
			1	24	48	72
49	38	52	61	72	68	36
50	48	62	74	78	90	65
52	51	81	92	105	88	48
53	82	108	121	128	104	72

THE P. V. : THE PORTAL VEIN

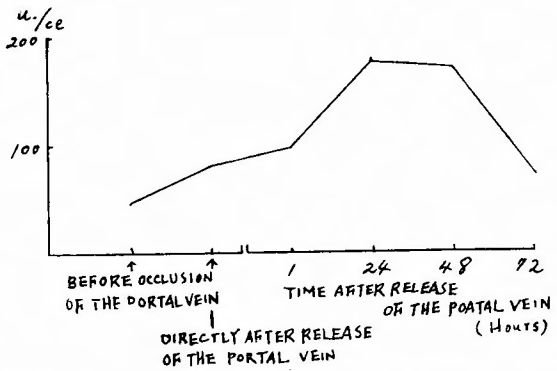


Fig. 5. Changes in the mean value of SGO-T activity after 30 minutes' interruption in Group A.

Most of animals undergone 45 minutes' and 60 minutes' interruption in the Group A died within a few hours after release of the interruption, therefore SGO-T activity after portal interruption was determined in dogs undergone 30 minutes' interruption.

In all of 5 cases of the Group A, SGO-T activity increased to its maximum of 104 to 280, 24 to 48 hours after the release of the interruption, which is as 3 to 5 times high

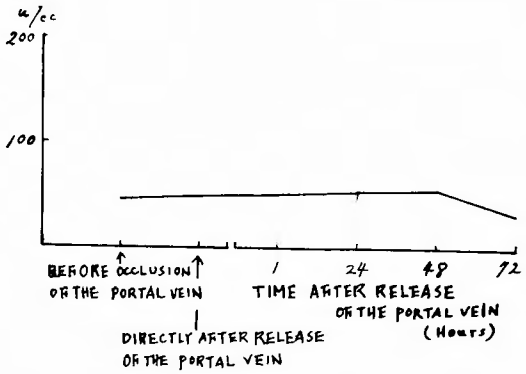


Fig. 6. Changes in the mean value of SGO-T activity after 30 minutes' interruption in Group E.

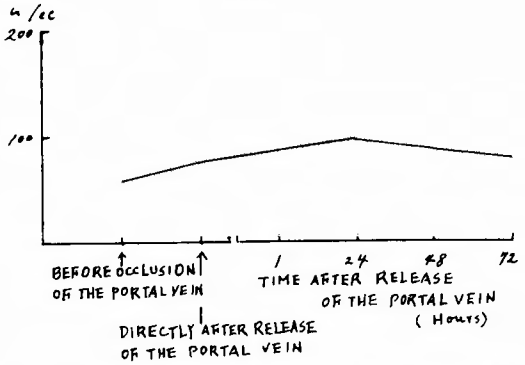


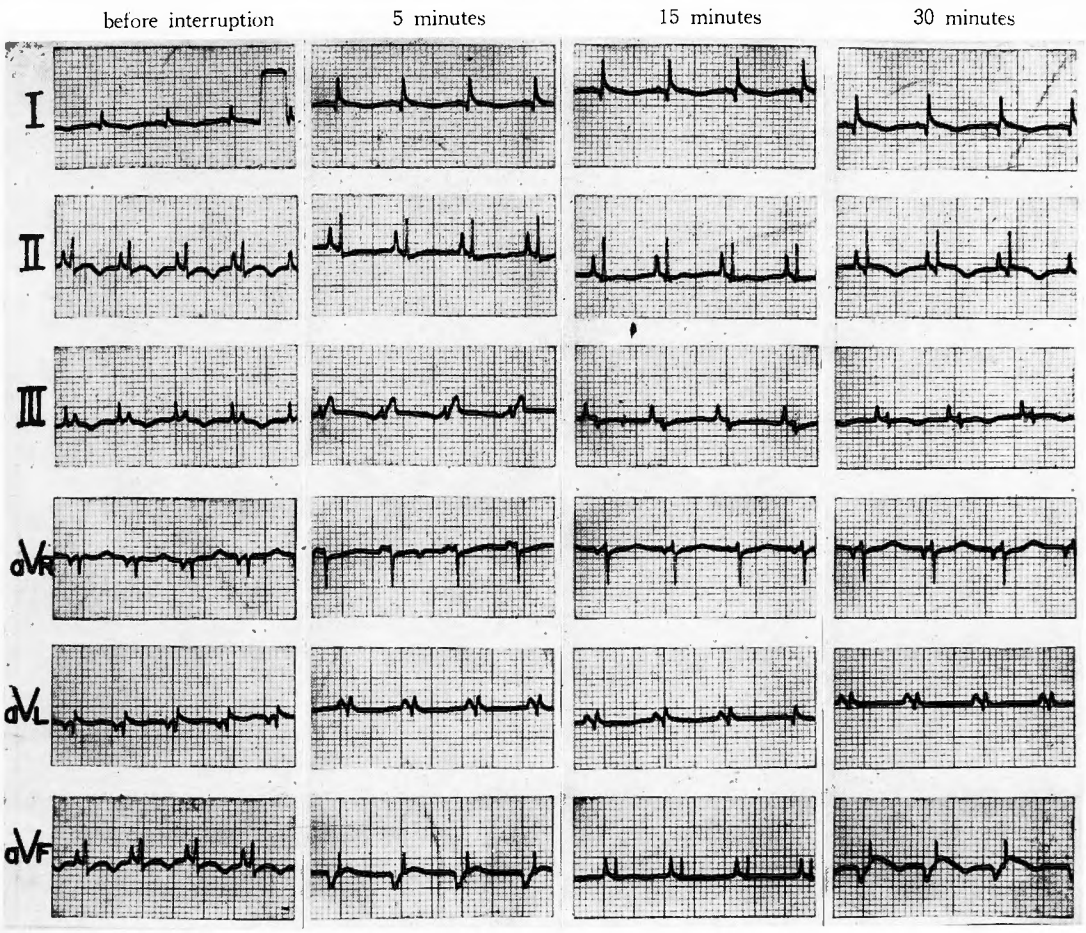
Fig. 7. Changes in the mean value of SGO-T activity after 60 minutes' interruption in Group E.

a level as compared with that before the interruption.

In the Group E, also SGO-T activity was observed to increase following the inter-

Fig. 8. Electrocardiogram in Group A.
Time after portal interruption

Fig. 9. Electrocardiogram in Group E.
Time after portal interruption



ruption. However, degree of increase 24 and 48 hours after the release of the interruption was slight compared with that of the Group A, its maximum value being 44 to 93 in the animals of 30 minutes' interruption and 72 to 128 in the animals of 60 minutes' interruption in the Group E, respectively.

6. Electrocardiographic changes after portal interruption (Fig. 8, 9).

Increased amplitude of P wave, ST-depression and low voltage were observed in all cases of the Group A.

On the other hand, any particular change was not observed in the Group E.

7. Histological findings after portal interruption.

Histological studies of the liver of the Group A and E revealed no particular abnormality in both survival and dead animals, except slight congestion in the intrahepatic portal system regardless of the duration of the interruption (Fig. 11).

In the intestine, edema, hemorrhage and hyperemia was observed in mucous membrane of the both groups in both survival and dead animals. Necrotic appearacne was not, however, observed (Fig. 12).

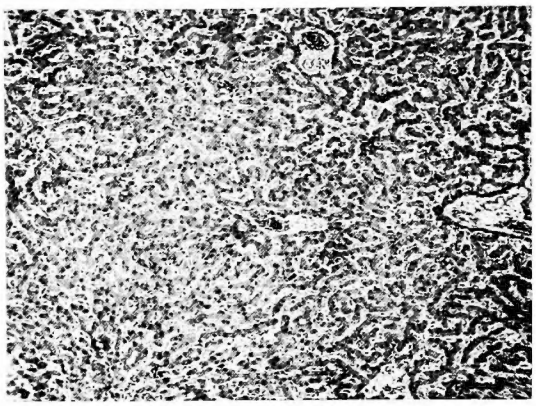


Fig. 11. Congestion in the intrahepatic portal system.

Fig. 12. Edema, hyperemia and hemorrhege in the mucous membrane of the intestine.

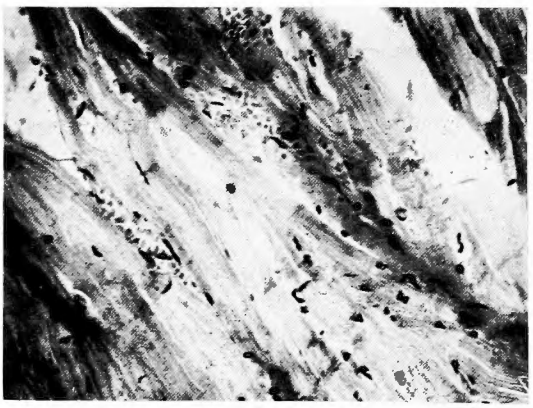


Fig. 13. Fragmentation of muscle fibres and hemorrhage of myocardium.

In the myocardium of the dead animals of the Group A, fragmentation and hemorrhage were observed. But these findings were not observed in surviving but slaughtered animals of the Group E (Fig. 13).

Ⅳ. DISCUSSION

In recent years, necessity of surgical procedure upon the portal vein has come to be emphasized, as the surgery of the liver and pancreas has made remarkable advance.

It has hitherto been common concept that acute occlusion of the portal vein invariably results in death.

Interval between portal ligation and death under normothermic condition has been reported to be about 2 hours by CHILD[12], 60 minutes by ELMAN and COLE[8], 50 to 90 minutes by NEUHOF[13] and 60 minutes by PECK[14]. On the other hand, concerning permissible time of transient portal interruption, Shimizu observed 3 survivals out of 3 cases of 15 minutes' interruption, 5 survivals out of 5 cases of 20 minutes' interruption, 2 survivals out of 4 cases of 30 minutes' interruption and 1 survival out of 5 cases of 40 minutes' interruption. The result of transient portal interruption of the author was 5 survivals out of 7 cases of 30 minutes' interruption and 1 survival out of 3 cases of 45 minutes' interruption. From these findings, it must be justifiable to conceive that the permissible time of the transient portal interruption would be 30 minutes.

When the superior and inferior mesenteric arteries were temporarily interrupted and splenectomy was addi-

tionally performed simultaneously with the transient portal interruption, 5 survivals out of 6 cases of 60 minutes' interruption were observed. In 75 and 90 minutes' interruption, however, survival was not observed.

The permissible time of portal interruption in the group of this operative procedure was 60 minutes. Thus the permissible time of portal interruption could be prolonged to 60 minutes, when the arterial blood flow to the splanchnic area is lessened by simultaneous splenectomy and temporary interruption of the superior and inferior mesenteric arteries.

LITTEN[16] observed rupture of venules and capillaries in the intestine of dogs 150 minutes after the interruption of the superior mesenteric artery.

NELSON and KREMMEN[17] reported one survival out of 4 cases of 4 hours interruption of the superior mesenteric artery and 2 survivals out of 2 cases of 2 hours' interruption of the artery. Judging from these findings, interruption of the superior and inferior mesenteric arteries in the present experiment was performed far shorter than the limit of permissible time of mesenteric arterial interruption.

On the other side, it is generally said that interruption of the celiac artery induces liver failure. IIZUKA[18] reported that a decrease in the activity of intrahepatic cytochrome-oxydase and succinic dehydrogenase become irreversible by an interruption of thoracic aorta for more than 60 minutes. SUGIMORI[19] reported that the degeneration of the liver was observed the most extensively by an interruption of abdominal aorta at the level just above the celiac artery, when compared with the results of interruption of the aorta at various levels. Accordingly in the present experiment, interruption of the celiac artery in the aim of decreasing arterial blood flow into the splanchnic area was not carried out.

As to the cause of death of the acute portal interruption, discussions have been reported, such as intoxication, neurogenic origin and hemorrhagic shock. THÖLE[7] insisted neurogenic factor which was based on his experimental results that some prolongation of permissible time of portal interruption could be observed in the dogs whose splanchnic nerve had been severed. PECK[41] attributed the cause of abrupt fall of arterial pressure which is observed following portal interruption to an irritation of the splanchnic nerve, and GAMMON[20] to an irritation to the splanchnic nerve and its terminal branches. ELMAN and COLE[8] postulated a decrease in circulating blood volume and intoxication, while SHORR and others[10] exphasized a decrease of visceral circulating blood volume and hypoxia. PECK[14] considered gradual secondary fall of arterial pressure to be due to a decrease of circulating blood volume. SISSON[21] reported hepatic blood flow of a dog weighing 10 kg to be 300 ml per minute, and BEST[22] described 75 per cent of this hepatic blood flow owes toportal blood. It is quite natural that effective circulating blood volume should be decreased if such a plenty amount of blood is pooled in the intestinal tract within a short period. In the present experiment also, when simple portal interruption was carried out, elevation of portal pressure and fall of arterial pressure were both pronounced with resulting small difference between these two pressures, whereas in the occasion in which temporary interruption of the superior and inferior mesenteric arteries and splenectomy were additionally carried out in the aim of lessening arterial blood flow into the splanchnic area, changes of the both pressures were mild with resulting large difference between these two.

Consequently cause of death after acute portal interruption may be considered to be due to decrease in circulating blood volume caused by congestion in the splanchnic area.

By the way Child asserted prosperous establishment of collaterals in apes, based on the observation that portal interruption was always fatal in dogs and rabbits, whereas in apes only 17 out of 76 cases died within several days after portal interruption.

Concerning liver changes after portal interruption, Child reported that after the interruption, the liver appeared to fade slightly in its tincture and to decrease in its volume, which, however, returned to normal state in a few minutes, and thereupon he concluded that particular change could not be observed in the liver after the interruption. In the present experiment, macroscopic findings roughly came to an accordance, and microscpically slight congestion was observed in the intrahepatic portal system.

Concerning the changes in the other abdominal organs caused by portal interruption, ELMAN and COLE[8] observed marked swelling of the spleen, conspicuous edema and congestion in the small and large intestines and stomach 3 to 6 hours after the interruption.

The finding that these changes in the stomach and large intestine are milder than in the small intestine might be due to the fact that portal system of these organs has communications in the upper abdomen with the esophageal vein via the gastric coronal vein and in the lower abdomen with systemic venous system via the left spermatic and superior hemorrhoidal veins.

Profound decrease in circulating blood volume caused by portal interruption subsequently brings about hypoxic change and decrease in oxygen supply in various organs. Such hypoxic change becomes the most pronounced in the myocardium.

Biochemical investigation of transaminase can be traced back to early days. It was, however, since 1954 that this became a clinical problem which was offered by the observation of LA DUE and others[24] that SGO-T activity was rapidly increased after acute myocardiac infarction. Thus the problem has come to be widely investigated in recent years. Transaminase is a ferment which transfers amino radical between amino acid and α-keto acid and is distributed widely in the tissues of animals and plants (Fig. 14). As is shown in Fig. 14, SGO-T acts upon aspartic acid and α-keto glutaric acid and converts these to glutamic acid and oxaloacetic acid. CHINSKY[25] reported that, in 98 per cent of acute myocardiac infarction, SGO-T activity arises to 40 to 200 units within 24 hours, which, however, restores relatively promptly to normal within 48 to 72 hours, and the degree of increase in SGO-T activity has close correlation to the extent of the lesion; in other words the higher the activity, the prognosis.

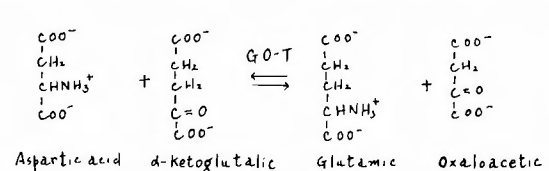


Fig. 14. Illustration of the effect of GO-T.

In the present experiment, changes observed in the heart after the interruption were assumed to be subendocardial and pericardial impairment. In other words, in the group, in which arterial blood flow in the splanchnic area was not controlled, lowering of ST, low voltage and sometimes negative T were observed electrocardiographically as early as

15 minutes after portal interruption. In these animals, SGO-T activity arose 24 to 48 hours after release of the interruption to as high a level as 3 to 5 times of preoperative level.

Histological study of these heart revealed fragmentation of muscle fibres and hemorrhage. TANTURI[23] reported that lowering of ST and negative T were invariably observed 10 to 40 minutes after portal interruption, and in 62 per cent of these animals lowering of ST was observed and amplitude of negative T increased in aVl lead 35 to 60 minutes after it. He also reported concerning SGO-T activity that the activity reached its maximum 24 to 48 hours after the interruption similarly to the result of the author. He postulated that such changes suggest widely spread ischemia in the subendocardium and pericardium and necrosis of upper lateral area of the left ventricle. TANTURI and others[14] observed histologically also fragmentation of myocardial fibres and hemorrhage.

In the present experiment, extended changes appeared in the myocardium, which is presumably due to decrease in circulating blood volume occurring necessarily in the group which underwent portal interruption alone. On the contrary, influence of the interruption was really slight in the group in which arterial blood flow into the splanchnic area was controlled.

V. SUMMARY

In the aim of prolongation of permissible time of portal interruption in dogs, arterial blood flow was controlled temporarily and following results were obtained;

1. Permissible time of portal interruption was 30 minutes in the group of mere portal interruption, 30 minutes in the group of simultaneous interruption of the superior mesenteric artery with portal interruption, 45 minutes in the group of simultaneous interruption of the superior and inferior mesenteric arteries with portal interruption, 30 minutes in the group of additional splenectomy and 60 minutes in the group of simultaneous interruption of the superior and inferior mesenteric arteries and splenectomy with portal interruption.

Arterial pressure, portal pressure, SGO-T activity, electrocardiogram and histological findings of liver, small intestine and heart in the group of simple portal interruption with resulting shortest permissible time of the interruption were compared after portal interruption with those of the group of simultaneous interruption of the superior and inferior mesenteric arteries and splenectomy with portal interruption with resulting longest permissible time of the interruption.

2. Arterial pressure showed abrupt fall immediately after portal interruption in both groups which gradually fell therafter. However, declivity of arterial pressure in the group of simultaneous interruption of the superior and inferior mesenteric arteries and splenectomy with portal intal interruption was more mild than in the group of simple portal interruption.

3. Portal pressure in the group of simple portal interruption showed its peak approximately 10 minutes after the interruption with resulting small difference from arterial pressure, which gradually fell in parallel with arterial pressure thereafter, whereas ascension of portal pressure in the group of simultaneous interruption of the superior and inferior mesenteric arteries and additional splenectomy was mild and difference from arterial

pressure also large.

4. Serum GO-T activity showed a high level as 3 to 5 times 24 to 48 hours after release of the interruption in the group of simple portal interruption, while it showed a level of 2 times only in some cases in the group of simultaneous interruption of the superior and inferior mesenteric arteries and splenectomy.

5. Electrocardiographically, lowering of ST, low voltage were observed 15 minutes after portal interruption in almost all cases in the group of simple portal interruption. On the contrary, particular change was not observed in the group of simultaneous interruption of the superior and inferior mesenteric arteries and additional splenectomy with portal interruption.

6. Histological study revealed slight congestion in the intrahepatic portal system, edema, hyperemia and hemorrhage in the mucous membrane of the intestine in the both groups and fragmentation of myocardial fibres and hemorrhage were observed in the heart of the dead animals underwent simple portal interruption, while no particular change was observed in the heart of the surviving animals undergone simultaneous interruption of the superior and inferior mesenteric arteries and splenectomy with portal interruption.

The author gratefully acknowledge the invaluable guidance of Prof. Dr. Ichio Honjo in these studies.

BIBLIOGRAPHY

1) Ore, M. : Influence de L'oblitération de la veine poste sur la sécrétion de la bile et sur la fonction glycogénique de foie. Compt. Rend. des Sciences., **43**, 463. 1856.
2) Schiff, M : Ueber das verhaltniss des Lebercirculation zur Gallenbildung. Ztbl. f. d. Med. Wiss., **1**, 115, 1863.
3) Bernard, C. M. Critique expérimentale sur la fonction glycogénésique du foie. Compt. Rend. L, Acad. des Sciences., **84**, 1201, 1877.
4) Solowieff, A. Veranderungen in der Leber unter dem Einflusse Kunstlicher Verstopfung der Pfortader. Virchow Arch. f. Path. Anat., **62**, 195, 1875.
5) Popper et al . A simple method of gradually producing permanent occlusion of poetal vein in the dog. Proc. Soc. Exper. Biol. and Med., **85**, 67, 1954.
6) Child, C. G. : Sudden and complete occlusion of the portal vein in the Macaca mulatta monkey. Ann. Surg., **132**, 475, 1950.
7) Thöle, F. : Verletzung der Vena Portae. Neue Deutsche Chir., Bd., 4. 131, 1912.
8) Elman, R. and Cole, W. H. : Loss of blood as a factor in death from acute portal obstruction. Arch. Surg., **28**, 1166, 1934.
9) Krymholz, M. L. : Experimenteller Beitrag zur Frage der Unterbindung der Pfortaderl (Einwirkung auf Druck und Gerinnungs-vermögen des Blutes). Z. exper. Med., **67**. 319, 1929.
10) Shorr, E. et al. : On the occurrence and site of vasotropic substance in traumatic shock. Science., **102**, 489, 1945.
11) Caubaud, P., Leeper, R. and Wröbleski, F. : Colorimetric measurement of SGO-T. Am. J. Clin. Path., **26**, 1101, 1956.
12) Child, C. G. : The hepatic circulation and portal hypertension. W. B. Saunders Co. Philadelphia and London 1954.
13) Neuhof, H. : Experimental ligation of the portal vein ; ite application to the treatment of suppurative pyiephlebitis. Surg. Gynec. and Obst., **16**, 481, 1913.
14) Peck, M. E. and Grover, R. F. : Cardiovascular responses to acute ligation of portal vein. Arch. Surg., **64**, 665, 1952.
15) Shimizu, Y. : A fundamental study on utilization of hypothermia in hepatic surgery. (in Japanese). Fukuoka Acta med., **50**, 7, 2140, 1959.
16) Litten, M : Ueber die Folgen des Verschluss der Arteria Mesaraica superior. Virch. Arch., **63**, 289, 1875.

Trans. asso. Amer. Phy. **2**, 121, 1887.
17) Nelson, L. E. and Kremen, A. J. : Experimental occlusion of the superior mesenteric vessels with special reference to the role of intravascular thrombosis and its prevention by heparin. Surg., **28**, 819, 1950.
18) Iizuka, T : Tissue respiration and histological observations of the liver after the temporary occlusion of the thoracic aorta. (in Japanese). J. Nagoya med. Ass., **69**, 1419, 1955.
19) Sugimori, A. : Experimental study on occlusion of the aortic blood flow. Juzen Igaku Z., **62**, 650, 1959.
20) Gammon, G. D. and Bronk, D. W. : Pacinian corpuscles in the mesentery and their relation to the vascular system. Proc. Soc. Exper. Biol. and Med., **31**, 788, 1934.
21) Sisson, S. : The anatomy of the domestic animals. revised by J. D. Grosaman, Ed. 3, Philaphia, W. B. Saunders Co. 1938, P. 512.
22) Best, C. H. and Taylor, N. B. : Physiological basis of medical practice. Ed. 4, Baltimore, Williams and Wilkins Co. 1945, P. 286.
-from 21) to 23) were cited from 14) Peck's article-
23) Tanturi, C. and Gomez, O. T. : Electrocardiographic and humoral changes in trancient occlusion of the portal vein in the dog. Surg. Gynec. and Obst., **110**, 537, 1960.
24) LaDue, J. S., et al. : SGP-T in hepatic disease. Ann. Int. Med., **45**, 801, 1956.
25) Chisky, M. and Sherry, S. : Serum transaminase as a diagnostic aid. Arch. Int. Med., **99**, 556, 1957.

和文抄録

門脈遮断に関する実験的研究

金沢大学医学部第2外科学教室（指導　本庄一夫教授）
小　柳　　弼

犬の門脈遮断許容時間を延長せしめる目的で，門脈領域流入動脈血を一時的に制限したところ，次のごとき成績を得た．

1．門脈遮断許容時間は，単独門脈遮断群30分，門脈遮断に上腸間膜動脈遮断を合併した群30分，門脈遮断に上，下腸間膜動脈遮断を合併した群45分，門脈遮断に脾剔出を合併した群30分，門脈遮断に上，下腸間膜動脈遮断，脾剔出を合併した群60分であつた．

門脈遮断許容前間の最も短かい単独門脈遮断群と，最も長い門脈遮断に上，下腸間膜動脈遮断，脾剔出を合併した群につき門脈遮断後の動脈圧，門脈圧，血清GO-T活性値，心電図，および肝，小腸，心筋の病理組織学的所見を比較検討した．

2．動脈圧は両群とも門脈遮断直後急激に下降し，その後も徐々に下降したが，上，下腸間膜動脈遮断，脾剔出を合併した群の門脈遮断後の動脈圧は単独門脈遮断群に比して下降勾配は小であつた．

3．門脈圧は単独門脈遮断群では門脈遮断約10分後に最高値をしめし，動脈圧と僅かの較差をしめすのみで，以後動脈圧と平行して徐々に下降した．上，下腸間膜動脈遮断，脾剔出を合併した群では門脈圧の上昇は軽度で動脈圧との較差も大であつた．

4．血清GO-T活性値は単独門脈遮断群では遮断解除後24乃至48時間にて3乃至5倍の高値をしめしたが，上，下腸間膜動脈遮断，脾剔出を合併した群では少数例が約2倍値をしめしたのみであつた．

5．心電図では単独門脈遮断群の全例にP波の増高，STの低下，低電位を認めたが，上，下腸間膜動脈遮断，脾剔出を合併した群では著変を認めなかつた．

6．組織所見では両群とも肝内門脈系に軽度のうつ血を認め，腸管では腸管粘膜に浮腫，充血を認めた．心筋では単独門脈遮断死亡群において心筋の断裂，出血を認めたが，上，下腸間膜動脈遮断，脾剔出を合併した生存群では著変は認められなかつた．